SIMULATION COUPLED WITH CBT CREATING A COMPREHENSIVE TRAINING TOOL THAT INCREASES TRANSFER

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ABSTRACT

Selective use of simulation in CBT increases training effectiveness. Simulations in CBT increase training effectiveness by presenting situations in the same manner as they are experienced in the real world. This increases learner transfer. However, simulations alone are not enough. While simulations allow the user to practice what-if scenarios, they lack content and instruction of proper methods and application. Without content and instruction for the user to access, misconceptions can result. Therefore, an effective CBT should have simulations paired with instruction; preferably, interactive lessons deigned to help the learner with specific problems and topics.

An approach has been developed using three different techniques for implementing effective simulations for CBTs: (1) Visual Simulations, (2) Modeling Behavior Simulations, and (3) Re-engineered Application Simulations. The first category uses bitmaps of the graphical user interface to mimic the way the application looks. This is a rudimentary form of simulation. In using this method, a trainer shows a series of actions and computer reactions, thus allowing the learner to see and also manipulate the interface. A second category models the engineering of the original application on another platform. Often requiring reverse engineering to simulate the device behavior, it allows the users to manipulate the interface just as they would in a real situation. It operates and reacts just as the original system. The third category uses the actual code used to create the original application in the simulation. The users interact with the system the same as they would in the reverse engineered model, but the cost of production of the simulation would be minimal and in fact allow the training simulation to be as up to date as the actual application.

In this paper, the benefits and limitations of each type of simulation will be analyzed ending in a proposal matching instructional goals with each form. After all, the goal of training is to attain a desired performance. The range of simulation technologies gives an instructional designer or trainer a choice. It is not always necessary to always implement the latest and flashiest of software. By matching effective instructional values with the appropriate technology, training can be more efficient and effective.

INTRODUCTION

If you were presented with a naval navigation system, would you feel comfortable with being responsible for the lives of those on your ship based on simply playing with the system for a few hours before embarking on a voyage? Personally, I would not. While I feel that I can learn any software package, the risk of not understanding all of the functionality would scare me. Similarly, how about the operators of production equipment in an automobile plant, would you let them jump onto the production line after they played around with the tools for a while knowing that mistakes can impact profits? There is risk to many forms of critical loss when operators are not trained to use complex systems properly, death, injury or profits for example.

Unfortunately, many training courses today are solely based on simulation. Operators are asked to, in all reality, play with the software or hardware for a limited period of time, then take on great responsibilities. Technology today allows trainers to develop simulations cheaper and faster than ever before and, therefore, it is getting even easier to jump on this trend in training (Salopek, 1998). Users need to be instructed about all the functions of complex systems, the standard practices and guidelines that others follow to ensure accuracy and safety. This knowledge cannot simply be acquired.

Complex Systems Require a Coupled Approach to Training

Complex systems refer to pieces of hardware or software that have dynamic interfaces with multiple functions. These are systems that have both a breadth of possible uses, and depth of procedures and techniques to execute those actions. This is to say that learning all the functions the correct way in a short period of time is not a trivial task.

In order to be sure the operators of complex systems understand both the how (procedures) and the why (rationale) for the actions, designers of training should properly match simulation techniques and tutorials to reach their instructional goals. Using simulation alone will not ensure that the user reaches all instructional objectives. Simulations do allow users to interact with the software or hardware, which helps to increase retention and transfer of skills, but what they will be remembering and doing is uncertain. Conversely, tutorials alone allow learners to gather facts about procedures, but how well they would be able to transfer that knowledge when asked to perform a task based on those procedures is unclear.

Coupled trainers provide tutorials to teach the ‘how’ and the ‘why’ of the new system and simulation to practice. There lies the heart of the argument; both simulation and tutorials are needed for effective instruction. Tutorials without any form of simulation deny the learner the opportunity to practice what they are being taught. Without “doing”, there is no real learning (Schank, Cleary, 1995). Simulations without tutorials do not give the learner the background understanding of why or how to properly execute their tasks.

The Context Is Everything

In order to properly teach anything, it must be understood why something is being taught. In addition to outlining goals and objectives, one must have a clear picture as to the importance or criticality of the course or lesson. The examples in this paper will deal with the teaching of complex systems that if used improperly can result in costly failures. The highly critical nature of these systems makes it important for users to know how to use all functions properly, in a way that follows safety precautions, in a timely and accurate fashion.

Design Models of Instruction

“What I hear, I forget; what I see, I remember; what I do, I understand.” - Confucius 451 BC

There are many models and theories about how learning environments should be sculpted and there are equally as many ideas about how individual lessons and learning modules should be designed. The key to effective instruction is matching the proper techniques to the learners and the desired goals. Considering factors about the learners’ past, their educational experiences, and the context in which the training will be presented will greatly enhance the effectiveness of the instruction. It will not guarantee how much learning will ensue, but properly assessing the situation offers the best chance for a positive outcome.

This paper is not going to prescribe to any particular model but rather suggest that a common thread of theory that lies in most models is that learning occurs when someone does something. Reading, hearing and seeing is valuable, but transfer and acquisition of skills is greatest when a learner actually practices the skills that are desired as outcomes. In Gagne’s *Nine Events of Instruction* it is held that after information is given, the learner should practice, then be given feedback to help shape the behaviors to the desired level (Gagne & Briggs,1979). One of the most powerful learning events is making a mistake and simulations provide this opportunity.

Discovery Learning and Experimentation

Some models of instruction contend that the most meaningful learning is done when the learner actually discovers or finds something to be true for themselves. This is not a point that we wish to argue, actually we agree with the natural learning process that those theories profess. The point of contention is the time, urgency and accuracy of those models of learning.

It is difficult to learn all of the functions of the complex systems that we are discussing in a timely manner. Also, if some functions are learned in an informal way, it is unlikely that the user would figure out the correct or most efficient procedure. A learning environment in which everyone developed their own procedures would lead to a number of processes being used. This can be particularly troublesome when re-enacting a situation and nobody knows what steps were performed in which order.

Other potential problems with relying on discovery techniques of the learner relate to the depth of the knowledge. It is very likely that when experimenting with the complex, only superficial functionality will become apparent. There will be no depth of understanding other than the “how to” aspect. By incorporating forms of tutorials in training, learners can practice the “how to” while learning about the “why”. This deeper understanding is very helpful in the decision making process.

Discovery learning also runs the risk of allowing misconceptions to form. To lower the chances of misconception formation, it is best to apply a scaffolded approach to training these systems. By applying multiple techniques to the learning process learners can be guided through the lessons moving from a very structured lesson, tutorial, to lock step practice then on to free interaction with the system. By moving a learner down a spectrum of practicing that starts with little to no simulation and mostly theory, to all simulation and no theory, one gains practice and understanding.

A MODEL FOR COUPLING SIMULATION WITH CBT

Instructional Objectives and Outcomes

Instructional objectives define the action or behavior that is expected of a learner after completing any form of training or instruction. They guide the instruction by giving the learners concrete goals to reach. Objectives also help designers of instructional products by guiding them in the content and exercises that are to be included in a lesson or course. Outcomes are a grouping or classification of objectives that define the level of cognitive understanding the learner is supposed to reach. There are many taxonomies that describe in full detail the types of learning that occur. For the purposes of this paper we will not describe all the known taxonomies, but rather discuss the six basic learning outcomes as described by Bloom. (This is appropriate since the goal of the paper is to make designers match technology with goals, not debate the finer points of the different classifications.)

It is important to have an understanding of the level of achievement expected from a learner before designing a course. This is in conjunction to knowing the objectives for the course. Knowing the level or degree of difficulty of the objectives for the learner can greatly aid in your design.

Below are Bloom's Six basic objective classifications:

1) Knowledge- Remembering or recognizing something without necessarily understanding, using or changing it. Basically recalling information.
2) Comprehension- Understanding the material being communicated without necessarily relating it to anything else.
3) Application- Using a general concept to solve a particular problem.
4) Analysis- Breaking something down into its parts.
5) Synthesis- Creating something new by combining different ideas.
6) Evaluation- Judging the value of materials or methods as they might be applied in a particular situation.
   (Bloom, Engelhart, Frost, Hill, & Krathwohl, 1956)

Efficiency and Effectiveness

Technology is amazing and additive. Users of it always crave more and fortunately (or unfortunately depending on your point of view), we live in a time where newer, faster and flashier technologies emerge everyday. The question is whether or not to use it.

Designers of instructional products should evaluate the technology and what it offers then match it to the goals that they are trying to accomplish. New technologies should be utilized for their instructional value, not for their capabilities. "How will this technology help to solve the training need?" The goal of training is to correct a performance problem, not impress a client with flashy products, that is a marketing goal.

Two types of efficiency must be considered when evaluating new technologies -- instructional and economical. Instructionally we want to be efficient and not give the learner more than is needed as to not overwhelm the learner and confuse the point of the instruction. By giving too much flash and capabilities the learner can loose focus and thus diminish the effectiveness of the product. Economically, using the wrong or inappropriate technology can unwisely consume time, money and resources in development.

The issues of efficiency and effectiveness come to the forefront when evaluating simulation technology. It is crucial to use the proper level of simulation to match the instructional goals. The proper simulation with the appropriate amount of instruction shapes the learning effectiveness, and also the development efficiency. Can you imagine how much time it would take to develop a flight simulation using only a series of bitmap images that accounted for user interactions? It would be equally as foolish to develop an elaborate mathematically modeled simulation to instruct an indicator change depending on whether a switch is in one of two positions.

States of the System

The state of a system refers to a unique mode or condition that a system can be in at a snapshot in time. In an effort to determine the difficulty in simulating a system, it is useful to examine the number of states that represent that system. For example a simple on/off switch has two states: on or off. A more complex system generally will have more states. For example, a panel of four on/off switches has 16 states. A very complex system, such as a flight management system in an airplane, will have many states, which can seem infinite at first glance. However, since our goal is training, not the pursuit of the perfect simulation, it may be possible to reduce the complex system to a discreet subset of states that will meet the instructional goal.

From a simulation point of view, the states themselves have a range of complexity, and therefore, an associated cost to develop a simulation for each state. The cost per state may not be calculable to an exact figure. It is generally possible to rank the cost per state relative to each other for a particular system.

The Decision Model

The following is a model for properly selecting the level of simulation to couple with a Computer Based Trainer (CBT) that will most effectively and efficiently reach your instructional goals. The idea of this model is to formalize a process for balancing financial and instructional needs.

Step (1): DETERMINE PERFORMANCE OBJECTIVE

Step (2): DETERMINE OUTCOME

Step (3): IDENTIFY SIMULATION TECHNIQUES (Note: examples of simulation techniques are presented later in the paper)

Step (4): FOR EACH SIMULATION TECHNIQUE IDENTIFY:

Step (4A): THE NUMBER OF STATES
Step (4B): THE COST PER STATE
Step (4C): AN EFFECTIVENESS RANK
Step (4D): AN EFFICIENCY RANK

Step (5): FILL IN THE "SIMULATION TECHNIQUE DECISION MATRIX" (see Table 1):

Table 1: Simulation Technique Decision Matrix

Simulation Technique	# of states	Cost/ state*	Effectiveness rank*	Efficiency rank*
Sim-Technique 1				
Sim-Technique 2				
Sim-Technique 3				

* Each form of simulation should be evaluated on a scale, 1 (least)- 5 (most)

Step (6): CHOOSE A SIMULATION TECHNIQUE

Step (7): IDENTIFY COUPLING TECHNIQUES (Note: examples of coupling techniques are presented later in the paper)
Step (8): FOR THE CHOSEN SIMULATION TECHNIQUE, DETERMINE PER COUPLING TECHNIQUE:

Step (8a): EFFECIVENESS RANK
Step (8b): EFFICIENCY RANK

Step (9): FILL IN THE "COUPLING TECHNIQUE DECISION MATRIX" (see Table 2)

Table 2: Coupling Technique Decision Matrix

Coupling Technique	Effectiveness rank*	Efficiency rank*
Couple-Technique 1		
Couple-Technique 2		
Couple-Technique 3		

Step (10): CHOOSE A COUPLING TECHNIQUE

SIMULATION TECHNIQUES

Overview

In order to make better use of the simulation/CBT-coupling model a definition of simulation and various techniques are required. Simulation is the computer-based representation of the function and operation of systems through the use of graphical representations for realistic appearance and mathematical models for realistic behavior. This simulation category is displayed on a computer monitor, or projected onto a screen, therefore, they are 2-dimmensional representations.

There are many techniques for implementing the appearance as well as behavior. Each has its own benefits and limitations.

Static Graphics

Static graphics are visual representations of a system that capture a single state of the system. When used alone they do not demonstrate behavior. However, when used in a series, like a slide show, they can be used to reveal multiple states of a system. Static graphics can be created today by the use of any drawing package that creates the popular formats such as BMP or JPEG.

They do not require programming skills nor intimate knowledge of the system that is being simulated. A graphic artist can design a static graphic representation from seeing the system first hand, a photograph, or engineering drawing.

Static graphics are not suitable for systems that need to have many states simulated. It quickly becomes a daunting task for the graphic artist to create an exhaustive set of static graphics. Furthermore, it becomes a daunting task for the programmer to choose and stream the correct static snapshots of the system. However, they can be used for a system that has many states where a subset of these states can be identified as required to meet the instructional goals.

A typical use of a static graphic simulation is in a control indicator application. A control is a device that changes the state of a system. An indicator is a device that displays the state of a system. A simple example is an on/off switch and an LED. There are only two finite states to instruct. Only four graphics are required (switch on, switch off, LED illuminated, LED not illuminated). When the user clicks on the graphic of the switch, the opposite set of graphics are presented.

Dynamic Graphics

Dynamic graphics are visual representations of a system that can capture multiple states of a system via property sheets. Property sheets are a table of parameters and their associated valid ranges. The user chooses the state of the graphic by setting the parameters to a particular value. Dynamic graphics can be implemented today by the definition of an ActiveX ® Control.

A graphic does not have to be created for every state of a complex system. The graphic artist only needs to create a graphic of the starting condition of the system. The programmer at runtime can set the dynamic state of the graphic.

A typical use of this type of simulation is a fairly complicated indicator device such as a Mile Per Hour (MPH) instrument. The property sheet for this dynamic graphic would have a single parameter for the MPH needle value. The graphic artist would create the background graphic. This is the visual representation of the indicator without the dynamic portion. In this example it would be the MPH instrument with the numbers (0.100), text labels, and hash marks. The background graphic would not include the actual needle that points to the current reading. The programmer would set the needle value either at design time or programming time. When displayed, the dynamic graphic would present the background graphic with the needle overlaid in the appropriate location.

It is important to understand the MPH gauge has no modeled behavior. It has no knowledge of the system that is setting its value. For example, if the MPH gauge is part of an automobile simulation, a separate model knows the state of the automobile and must set the MPH gauge accordingly.

Modeled Behavior

For more complicated systems that have many dynamic states a mathematical model is required. The model replicates a system by using mathematical data to define the relationships among its subelements. The mathematical data is created by making inferences based upon the system performance and operation. This type of modeling is often referred to as "reverse engineering" because the simulation engineer's task is to emulate the engineering work done by the original creators of the system. This type of simulation can provide the user freeplay functionality. A student can perform any procedure in any order as if they were actually operating the system. Modeled behavior can be implemented today through many popular programming languages such as C++.

The limitations of modeled behavior simulations are directly tied to the limitations of the programming. It is conceivable that with unlimited resources any system could be simulated to 100% accuracy. In reality we do not have unlimited resources. Therefore, the limitations must be set during the analysis phase of a project.

Two factors should be considered when choosing the fidelity of the simulation:

(1) Operational performance – Does the model look and feel like the real system? The model should not portray any unrealistic time delays or display differences.
(2) Instructional performance – does the model support meeting the instructional objectives? The accuracy

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of the model should be limited to only what is instructionally needed. For example, if the goal of a simulation is to instruct a pilot on the correct procedures for using the engine fire extinguisher system, it would probably be reasonable to simulate several aircraft controls and indicators. However, a full flight model with artificial scenery would probably not be required.

The fidelity chosen for the model will dictate its application (see Table 3).

Table 3: Levels of Fidelity

Fidelity	Description
I	System functionality is modeled, not system states; fault-free system simulation is provided only; simulation is based on empirical inference.
II	Fault and fault-free system simulation of system components; correct modeling of system static states within the actual system tolerances; simulation depicts some dynamic system states.
III	Mathematically correct component-based model; accurately simulates dynamic states, faults and fault effects of individual components. Replicated system static dynamic response is within tolerances of actual equipment,

(NAMTRAGRU, page 5-3)

An example of a Level II simulation is a maritime navigational trainer for digital nautical charts that provides:

- Realistic representation of the digital nautical chart
- Accurate modeling of a steerable vessel layered on the chart
- Dynamic states of alarms to the system tolerances
- Injection of system failures
- Limitations on what charts are made available
- Limitations on the simulation of the sensor data to not be within the tolerances of the actual equipment

Re-engineered Software Simulations

Another technique can be used instead of modeled behavior for complex systems. Re-engineered software is the process of re-using the software from the system that is to be simulated. Two methods can be used:

(1) Re-hosting – The executable software is left untouched. It is transplanted from the original system to the simulation system. This method is most feasible when the simulation system and real system are quite similar and probably employ the same operating system and family of CPU. Often a software "wrapper" will have to be developed around the original executable in order to transplant it untouched.
(2) Re-targeting – The original source code is re-compiled to run on the target simulation system. Often some of the software will need to be modified in order to make it compatible with the simulation operating system and CPU. Furthermore, external interfaces will have to be simulated or stubbed out.

Re-engineered software simulations can be implemented today through many popular programming languages such as C++.

This type of simulation can offer the same free-play benefits at reduced lifecycle cost. The savings come from re-using original system software instead of re-engineering it from scratch. There can also be long term maintenance savings if software changes to the real system can easily be integrated into the simulation.

Re-engineering has several limitations that must be considered. The simulation engineers must have access to the real system software. If the host and target computers are drastically different then re-hosting may be impossible. If there are many dependencies to external interfaces and sensors, much software will still have to be developed to simulate those interfaces. Because changes will inevitably have to be made to the simulated system, integrating changes can be complicated and break the original modifications.

An example of a re-targeted simulation is a system that re-uses the software from an actual flight management system. Such a simulation is comprised of re-compiling the real system source code for execution on a personal computer. The sensors and interface are simulated in new software leaving as much of the original core untouched.

An Example “Simulation Technique Decision Matrix”

Using the techniques described above the “Simulation Technique Decision Matrix” can be updated to (see Table 4):

Table 4: Updated Simulation Technique Decision Matrix

Simulation Technique	# of states	Cost/ state*	Effectiveness rank*	Efficiency rank*
Static Graphic				
Dynamic Graphic				
Modeled Behavior I				
Modeled Behavior II				
Modeled Behavior III				
Re-engineered Software				

COUPLING TECHNIQUES

Overview

To further enhance the Simulation/CBT Coupling model methods of coupling must be understood. The combination of simulation and CBT can be delivered to the student using various techniques. The coupling technique is an independent choice from the simulation technique. Any simulation technique can work with any coupling technique. Each offers benefits and limitations that also should be considered.

On-Demand Coupling

In on-demand coupling both the simulation and CBT components are delivered to the student but neither has cognizance of the other, in that they don’t effect the operation of the other. The student must choose when to examine tutorials and when to use simulation for practice.

The student has total control to learn from the CBT components and practice in the simulation components. The simulation and tutorial can reside completely separate on one CBT or they can be right next to one another but the user still has complete control over whether they will continue with the tutorial or simulate skills learned.

In on-demand coupling there is no assistance offered to the student while in the simulation mode. Therefore, confusion and frustration can occur.

Lockstep Coupling

Lockstep coupling reduces the complexity of learning a system by prescribing defined methods or procedures. The instruction and simulation alternates in its presentation. The procedure will be explained then followed with the simulation to perform it.

The entire behavior of a system does not have to be simulated or instructed. Only the predefined methods of interacting with the system are developed.
The lack of free exploration can lead to slow, repetitious, training.

There are various degrees in the lockstep method. In its most basic form, a trainer will say do step A, the learner does A, then the trainer moves on to step B and so on. Other implementations may give a user a few steps then have them perform those tasks. This is similar to the next section, Guided Coupling, but it all works on a spectrum. In either case, procedures and reasons for those steps are given with practice.

Guided Coupling

In guided coupling the CBT acts as an agent monitoring the student during a simulation session. The agent can intervene when the student goes astray and offer assistance. There are many degrees to which this technique can be implemented. On the simplest level the guided coupling can be a small expansion on lockstep coupling. A list of procedures can be taught then offered for practice via simulation. The agent monitors the student as each step is performed and intervenes if the student goes off track. A more complex implementation would utilize an advanced agent that has aspects of artificial intelligence (AI). This AI agent could monitor the student in more complex situations that are not simply procedural, offering insights that are adapted to the user.

The CBT is somewhat adaptive to the student. The student can freely explore and will only be offered assistance when it is needed.

There are a wide variety of techniques that can be used in guided coupling. The programming can become quite complex if the expectation for the guidance is set too high.

An avionics maintenance technician is presented with a simulation of a faulty system. The technician is free to explore the faulty system with various simulated pieces of diagnostic equipment. The agent monitors the technician and offers guidance to the proper use of the diagnostic equipment and hints about what is wrong with the faulty system.

An Example "Coupling Technique Decision Matrix"

Using the techniques described above the "Coupling Technique Decision Matrix" can be updated to (see Table 5):

Table 5: Updated Coupling Technique Decision Matrix

Coupling Technique	Effectiveness rank*	Instructional Efficiency rank*
On-Demand		
Lockstep		
Guided		

CASE STUDY

The authors recently completed a computer based training solution that utilized most of the simulation spectrum to reach the gamut of instructional outcomes. It is evident that in this example alone that coupling the proper amount of simulation can greatly enhance a training product's effectiveness. The simulation/CBT-coupling model was utilized in the design of the trainer.

Navigation Sensor System Interface (NAVSSI) is the system that the U.S. Navy uses to integrate the inputs from various shipboard navigation sensor systems, distribute the integrated navigation solution to shipboard users and provide a dedicated workstation to the ship's navigation. This workstation uses sensor data and along with Digital Nautical Charts (DNC), maps, to let Naval Quartermasters navigate. Any training was tasked with teaching the operators of that system all of its functionality, procedures and system architecture.

There were a number of learning objectives that fit into each of the knowledge, comprehension, application, analysis, synthesis and evaluation categories.

Example 1

Night vision is a computer display function that allows operators to adjust the brightness of the screen so it is visible in different natural lighting settings.

Step (1): DETERMINE PERFORMANCE OBJECTIVE

Learners will be able to properly choose a night vision setting based on the time of day.

Step (2): DETERMINE OUTCOME CLASSIFICATON

Application and Comprehension

Steps (3...5) "SIMULATION TECHNIQUE DECISION MATRIX" (see Table 6)

Table 6: Simulation Decision For Example 1

Simulation Technique	# of states	Cost/ state*	Effectiveness rank*	Efficiency rank*
Static Graphic	15 (a)	1	4	5
Dynamic Graphic	25 (c)	3	4	4
Modeled Behavior I	1000 (b)	3	3	3 (d)
Modeled Behavior II	1000 (b)	4	3	2 (d)
Modeled Behavior III	1000 (b)	4	4	2 (d)
Re-engineered Software	1000 (b)	N/A	N/A	N/A

Notes:

a) *15 different shades of darkness are enough to show the use of the function.*

b) *There are actually 1000 states on the actual system.*

c) *25 different states would probably give the needed fidelity.*

d) *The level of fidelity would be beyond the users' need.*

Step (6): CHOOSE A SIMULATION TECHNIQUE

The choice of static graphic combines high effectiveness, high efficiency and low cost.

Step (7…9): "COUPLING TECHNIQUE DECISION MATRIX" (see Table 7)

Table 7: Coupling Matrix for Example 1

Coupling Technique	Effectiveness rank*	Instructional Efficiency rank*
On-Demand	3 (b)	5 (c)
Lockstep	3 (a)	4 (d)
Guided	4	N/A (e)

Notes:

a) *By telling users to do a step and see the effects, it limits the users' ability to learn how each state would be effective.*

b) *The possibility of users that need the practice may skip this exercise.*

c) *User control is provided for to account for more expert users.*
d) *Lockstep is less efficient due to the length of time it would take to explain an apparent function.*
e) *There is no monitoring to be accomplished in this practice situation.*

Step (10): CHOOSE A COUPLING TECHNIQUE
It is recommended to use a series of static images and couple them in an on-demand fashion. Since no one technique stands out as being incredibly more effective than another, this technique's efficiency stands out.

Example 2
One way to determine range and bearing from one point on a map to another is to click the first and move the cursor over the second. NAVSSI determines the needed information.

Step (1): DETERMINE PERFORMANCE OBJECTIVE
The learner will be able to report range and bearing using the cursor function.

Step (2): DETERMINE OUTCOME CLASSIFICATON
Comprehension and Application

Steps (3...5) "SIMULATION TECHNIQUE DECISION MATRIX" (see Table 8)

Table 8: Simulation Decision For Example 2

Simulation Technique	# of states	Cost/ state*	Effectiveness rank*	Efficiency rank*
Static Graphic	∞	N/A (a)	N/A	N/A
Dynamic Graphic	∞	4 (a)	4	4
Modeled Behavior I	∞	2 (a)	3	4
Modeled Behavior II	∞	3	5	4
Modeled Behavior III	∞	5 (b)	5	3
Re-engineered Software	∞	N/A	N/A	N/A

Notes:
a) *Fidelity does not provide enough realistic feedback to the user.*
b) *Fidelity would be very effective, but cost is too high.*

Step (6): CHOOSE A SIMULATION TECHNIQUE
Modeled Behavior II provides the need effectiveness at a reasonable cost.

Step (7...9): "COUPLING TECHNIQUE DECISION MATRIX" (see Table 2)

Table 9: Coupling Matrix for Example 2

Coupling Technique	Effectiveness rank*	Instructional Efficiency rank*
On-Demand	2 (b)	5 (a)
Lockstep	4 (c)	2 (a)
Guided	5 (a)	2

Notes:
a) *Given the range of the students it is desirable to allow experts to skip the exercise.*
b) *The possibility of users that need the practice may skip this exercise.*
c) *Prevents users from skipping needed practice.*

Step (10): CHOOSE A COUPLING TECHNIQUE
It is recommended that a Modeled Behavior II simulation is coupled in an On- Demand way. Due to the simplicity of this function, user control is considered to be a priority. This will help to keep the higher end learners interested longer.

Example 3
Much of the course is taught in a step by step fashion where the procedures may seem independent of one another. This objective is one of many aimed at placing those procedures in a context.

Step (1): DETERMINE PERFORMANCE OBJECTIVE
Learner will combine many procedures to properly lay a trackline and set a course.

Step (2): DETERMINE OUTCOME CLASSIFICATON
Application and Synthesis

Steps (3...5) "SIMULATION TECHNIQUE DECISION MATRIX" (see Table 10)

Table 10: Simulation Decision For Example 3

Simulation Technique	# of states	Cost/ state*	Effectiveness rank*	Efficiency rank*
Static Graphic	L[1]	1	4	5 (d)
Dynamic Graphic	L[1]	3	3	3
Modeled Behavior I	L[1]	3	3	3
Modeled Behavior II	L[1]	5	3 (c)	3 (b)
Modeled Behavior III	L[1]	5	3 (c)	3 (b)
Re-engineered Software	L[1]	N/A	N/A	N/A

1- Limited number of states

Notes:

a) *There are a limited number of correct states because there are only so many correct paths.*
b) *The amount of functionality could allow for confusion to set in.*
c) *Confusion greatly undermines effectiveness.*
d) *A series of static images only gives the user what they need to accomplish the task.*

Step (6): CHOOSE A SIMULATION TECHNIQUE
In this case, because all user interactions could be determined, it is best to use static images. Other options would give the user too many possibilities for error.

Step (7...9): "COUPLING TECHNIQUE DECISION MATRIX" (see Table 11)

Table 11: Coupling Matrix for Example 3

Coupling Technique	Effectiveness rank*	Instructional Efficiency rank*
On-Demand	3	2 (a)
Lockstep	1 (b)	3
Guided	4	4

Notes:

a) *On- demand has simulations running independently. In the early synthesis forming, users should need feedback to be sure misconceptions do not form.*
b) *Too restricting to allow users to synthesize information.*

Step (10): CHOOSE A COUPLING TECHNIQUE
It is recommended that the coupling take on a Guided approach. Users need to be able to perform functions as if on a ship, but also need an agent to be watching that correct procedures are being used.

Example 4

The NAVSSI system offers the user many functions that make many traditionally paper based seem simple, but not all. It is important for the user to explore the system and discover what they can accomplish and what the system restricts them from doing.

Step (1): DETERMINE PERFORMANCE OBJECTIVE
Learners will be able to list the limitations of the NAVSSI system.

Step (2): DETERMINE OUTCOME CLASSIFICATON
Evaluation
.

Steps (3...5) "SIMULATION TECHNIQUE DECISION MATRIX" (see Table 12)

Table 12: Simulation Decision For Example 4

Simulation Technique	# of states	Cost/ state*	Effectiveness rank*	Efficiency rank*
Static Graphic	∞	N/A (b)	N/A (b)	N/A (b)
Dynamic Graphic	∞	5	2 (d)	3
Modeled Behavior I	∞	5	3 (d)	3
Modeled Behavior II	∞	4	5	5
Modeled Behavior III	∞	5 (c)	5	5
Re-engineered Software	∞	N/A (a)	N/A (a)	N/A (a)

Notes:

a) *Access to the original software is not possible.*
b) *There are too many possibilities to capture all states.*
c) *This would be ideal, but the extra cost far exceeds its value to the user.*
d) *Fidelity would not be high enough to allow the users to accomplish their goal.*

Step (6): CHOOSE A SIMULATION TECHNIQUE
A modeled behavior simulation best allows the users the fidelity that they need and at a reasonable cost.

Step (7...9): "COUPLING TECHNIQUE DECISION MATRIX" (see Table 13)

Table 13: Coupling Matrix for Example 4

Coupling Technique	Effectiveness rank*	Instructional Efficiency rank*
On-Demand	5	5
Lockstep	1 (a)	N/A
Guided	1 (a)	N/A

Notes:

a) *A user cannot evaluate a system with any form of restraints on the ability to use the system.*

Step (10): CHOOSE A COUPLING TECHNIQUE
A user needs an on-demand configuration in this instance. The expected evaluation outcome requires that the user be free to play with the system.

CONCLUSION

Notice that all of the above examples directly relate to an objective. After all, the reason for training is to reach a goal. Choices were also made in other areas based on the importance of the objective in the scope of the entire course. In the NAVSSI trainer, simulation was used in a number of ways in order to reach a number of different objectives or varying levels of performance.

Using the Simulation/CBT coupling model decisions can be made that will maximize trainer efficiency and effectiveness while considering development cost. The techniques for simulation and coupling can be refined or expanded upon to tailor the decision model to any trainer application.

REFERENCES

Bloom, B.S., Engelhart, M.D., Frost, E.J., Hill, W.H. & Krathwohl, D.R. (1956) Taxonomy of educational objectives. Handbook I: Cognitive domain. New York: David McKay

Gagne, R.M., & Briggs, L.J. (1979). *Principles of instructional design* (2nd ed.). New York: Holt, Rienhart & Winston

Naval Air Maintenance Training Group Computer Based Training Conventions and Standards Style Guide, page 5-3

Salopek, Jennifer J. (1998, August). Workstation meets playstation. Training & Development, 26-35.

Schank, Roger C., Cleary, C.(1995) *Engines for Education.* Lawrence Erlbaum Associates, Publishers: New Jersey. P. 74